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SUCROSE AND WATER CONSUMPTION BY RATS EXPOSED TO GAMMA-NEUTRON RADIATION

ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
Defense Atomic Support Agency
Bethesda, Maryland

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SUCROSE AND WATER CONSUMPTION BY RATS
EXPOSED TO GAMMA-NEUTRON RADIATION

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ABSTRACT

This study examined the possible use of sucrose and water as reinforcers in behavioral studies of rats, after low dose gamma-neutron irradiation. Twenty-four rats were offered a choice of a 10 percent sucrose solution or distilled water *ad libitum*. Another 24 rats received only distilled water. Of the 24 rats in each of the above groups, three subgroups of six rats each received 120, 260 or 520 rads of mixed gamma-neutron radiation. The fourth subgroup of six rats was sham irradiated. Two days after irradiation, the subgroups that had been offered sucrose and water developed a significant aversion to the sucrose solution, and simultaneously increased their consumption of water. The subgroups receiving only distilled water decreased their consumption by the second day postirradiation. The most significant decrease in water consumption was observed in the rats receiving water only and 520 rads of radiation. The results suggest that the changes in consumption of sucrose and water caused by irradiation eliminate their use as reinforcers in behavioral experiments with radiation.

I. INTRODUCTION

Changes in the feeding behavior of animals subjected to ionizing radiation have been observed under various experimental conditions. These changes are important factors in behavioral studies which use nutrients as reinforcers. Langham and co-workers observed that primates exposed to lethal doses of radiation lacked motivation for food.[4] A recent investigation on the nutrient intake of rats exposed to 375 rads of x irradiation suggested that changes in a free-choice situation demonstrated possible metabolic derangements or imbalance.[3]

Numerous investigations have attributed the changes in feeding and drinking behavior of irradiated rats to conditioned aversion. This effect, reviewed in a recent book by Kimeldorf and Hunt,[2] occurs with both saccharin and sucrose solutions. Although all the factors involved have not been identified, other studies have indicated that the changes cannot be explained by aversion to drinking or by alterations in thirst.[6]

The purpose of this study was to examine the possible use of sucrose and water as reinforcers in behavioral studies with rats exposed to low-dose gamma-neutron irradiation. An experiment was designed to study the effects of three levels of radiation upon the daily intake of water and sucrose. Male and female rats were used to evaluate possible variation in liquid intake due to size or weight differences. This experiment may provide a basis for future studies in rat maze learning and in task performance by the irradiated monkey.

II. METHODS

Forty-eight Sprague-Dawley rats were used as the subjects in this investigation. Twenty-four males and twenty-four females, selected from a group of weanling rats, were housed in individual cages on a standard, double-sided rack that was placed in a constant temperature (70°F) and humidity (50 percent) environment.

Subjects of each sex were randomly assigned to four treatment groups with each group composed of six males and six females. Half of the animals were maintained on Purina Laboratory Chow and distilled water. The other half received the same diet and, in addition, a 10 percent solution of sucrose. All nutrients were offered *ad libitum*, with the water and sucrose containers being rotated daily to prevent the development of position habits.

The 5-day preirradiation schedule consisted of daily measurements of weight, water consumption and, where applicable, sucrose consumption. After the daily measurements were made on the 5th day, each of the four groups of rats were taken from their home cages and placed in cylindrical plastic containers. These containers were stacked eight cages high in wooden racks.

The racks containing the groups to be irradiated were positioned in the exposure room such that the rats were perpendicular to the line between themselves and the reactor core. These positions were determined from previous flux mapping dosimetry experiments. The fourth group which served as a control was placed in an adjacent room to simulate the exposure facility.

The radiation source was the AFRRI-TRIGA reactor using the steady-state mode of delivery. The gamma to neutron ratio for the delivered doses was approximately

60 to 40.[5] The doses were determined by measurements made both prior to and during irradiation with 50 cm^3 tissue-equivalent ionization chambers filled with tissue-equivalent gas.[1] The calculated doses for the three groups of rats are shown in Table I. The estimated precision of the total dose is ±10 percent.

Table I. Experimental Groups

Group		I	II	III	IV
Radiation	Dose rate (rads/min)	0	48	104	208
	Total dose (rads)	0	120	260	520
Diet	Water	3♂ 3♀	3♂ 3♀	3♂ 3♀	3♂ 3♀
	Water + sucrose	3♂ 3♀	3♂ 3♀	3♂ 3♀	3♂ 3♀

Within 1 hour following irradiation, the animals were returned to their home cages. All subjects were offered their assigned preirradiation diets between 1 and 2 hours postirradiation. The 4-day postirradiation schedule consisted of daily weighings and liquid consumption measurements.

III. RESULTS

The analysis of variance technique was used to test for significant factors affecting sucrose and water consumption. Radiation dose, subject sex, and days postirradiation were the factors included in the analysis. All interactions among the above factors were also hypothesized and tested for significance. Tests for differences in the quadratic trends were performed for the dose by day profiles. This model was

tested on the basis of a hypothesized increment or decrement in consumption followed by a return to normal level.

The significant ($P < .01$) dose by day interaction for the sucrose variable is plotted in Figure 1. The largest daily decrease in consumption for all groups occurred on the 2nd day postirradiation. A recovery to the control group level of sucrose consumption is indicated in each irradiated group, with the rate of recovery inversely related to the magnitude of the radiation dose. These profiles did not show significantly different quadratic trends, which may be due to the simultaneous decrease on the 2nd day and the lack of return to control levels by two groups on the 4th day postirradiation. Thus, any differences in these profiles may be explained by negative linear trends.

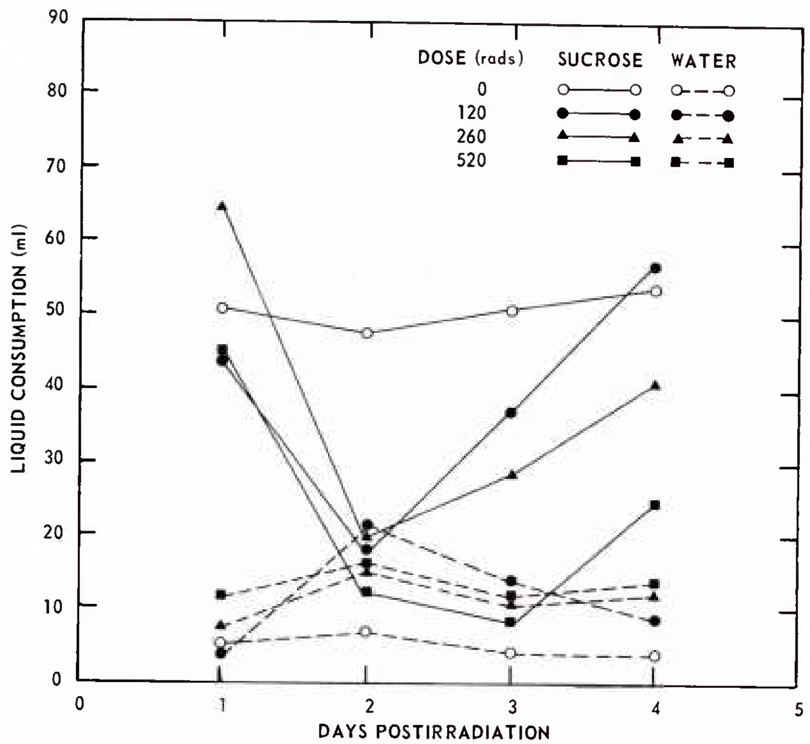

Figure 1. Postirradiation liquid consumption for the groups offered both sucrose and water

The daily changes in water consumption by the irradiated groups were in the opposite direction of the observed changes in sucrose consumption. In almost every case a decrease in sucrose solution intake during a single day was paralleled by an increase in water intake for the group. The only exceptions to this inverse relationship occurred on the 3rd and 4th days postirradiation for the 520-rad group and on the 4th day postirradiation for the 260-rad group. Figure 1 depicts the changes that occurred in water intake of the groups offered sucrose solution ad libitum. The test on the overall interaction of radiation dose with day postirradiation did not indicate significance, but differences in quadratic trends were significant at the .05 level.

Water consumption by the irradiated groups not offered sucrose solution showed an opposite trend to that evidenced by the irradiated animals offered sucrose. The daily consumption for the groups not offered sucrose is depicted in Figure 2. As with the groups offered sucrose, recovery is indicated by the 3rd or 4th day postirradiation. Daily differences in water consumption by the different dose groups were indicated by a significant ($P < .01$) dose by day interaction. Differences in quadratic trends for the groups, as shown in Figure 2, were significant at the .05 level. This difference is most evident in the consumption for the 520-rad group which showed a much larger decrease than that for the other two irradiated groups, with recovery evident by the 4th day postirradiation.

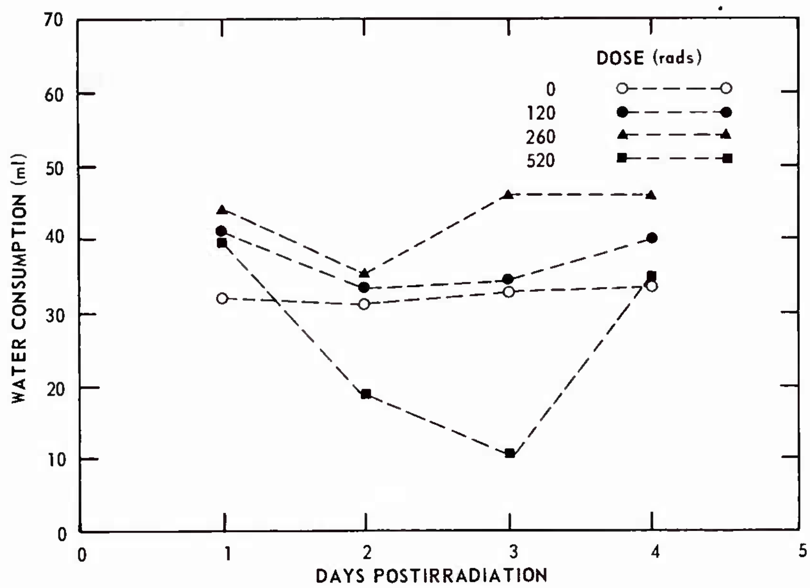

Figure 2. Postirradiation liquid consumption for the groups offered only water

IV. DISCUSSION

This experiment shows a decrease in sucrose consumption by rats after exposure to gamma-neutron radiation similar to that reported by Konishi[3] following exposure to x rays. Both of these experiments were conducted under free-choice conditions.

The changes in water intake by the irradiated groups offered sucrose also showed similarities to those shown by Konishi.[3] Konishi attributed the increase in water intake postirradiation to only a few individuals whereas the results of this study show the changes to be significant. In the present study, water intake changes are possible evidence of the aversion to sucrose since the sucrose was in a solution which represented a large portion of the animals' total liquid intake.

The strong aversion postirradiation to sucrose in solution and the alteration in water intake in the free-choice situation combined to show daily fluctuations in total liquid intake. A corresponding change in liquid consumption was also shown in the irradiated subjects not offered sucrose. This indicates a complex interaction of physiological factors affecting motivation. The latency, duration, and magnitude of these effects are dose-related.

It is concluded that the use of water or sucrose as positive reinforcers in behavioral experiments following gamma-neutron irradiation is not practical even at sublethal doses. It appears that changes in motivational levels related to unidentified physiological effects would greatly confound the results. Further study under controlled experimental deprivation and environmental conditions is needed to define the changes for a specific schedule.

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